



Indoor Environment Quality Assessment

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Outline of today's presentation

- ❖ Introduction & Motivation
- ❖ Objective Measurement
 - ❖ Equipment set-up
 - ❖ Results
- ❖ Subjective Measurement: Surveys
- ❖ Conclusions

Introduction and Motivation







- > **Green Building 101 [USGBC.org]: The Indoor Environment Quality [IEQ] “encompasses the conditions inside a building” such as**
 - Thermal conditions
 - Air quality
 - Lighting
 - Acoustics
 - Ergonomics
- and their effects on occupants.**
- > **Better IEQ can “enhance the lives of occupants, increase the resale value of a building and reduce liability for building owners.”**

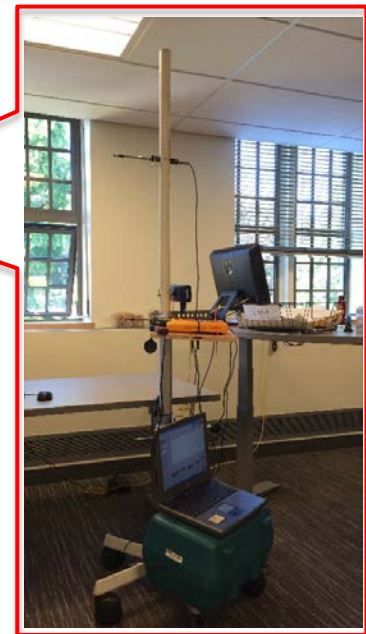
Primary research question: Does LEED Gold status ensure high IEQ in practice?

- > In order to answer this question, we collected both objective and subjective data in-situ for the Husky Union Building (HUB), which is LEED-Gold.



Objective measurements: Equipment Set-up

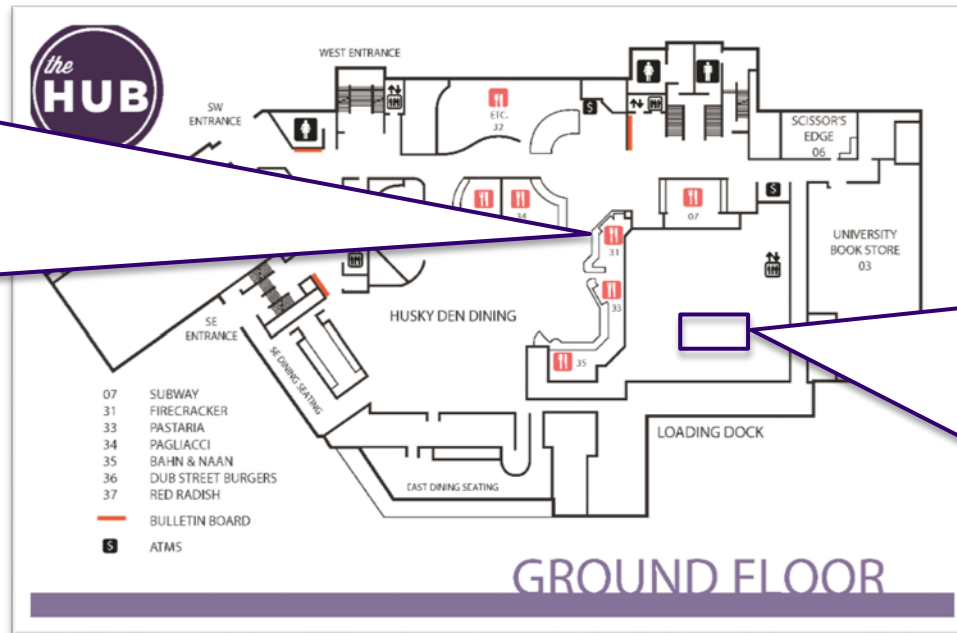
| | | | | | | |
|--------------------|---|---|--|---|---|---|
| |  |  |  |  |  |  |
| Model Name | Fluke 975V Air Meter | REED SD-4214 Thermo-Anemometer/Datalogger | REED SD-4023 Sound Level Meter/Datalogger | HOBO U12-012 Temp/RH/Light/External USB Logger | EXTECH HT30 Heat Stress WBGT Meter | Telaire 7001 CO ₂ Sensor |
| Measurement | Relative Humidity + CO ₂ | Air Temperature + Air Velocity | Sound Level | Light Intensity + Relative Humidity | Globe Temperature | CO ₂ Level |



Measurement Location II

- > To study the indoor environment of Husky Den dining area, the Firecracker station was selected as a test location as well as the dishwashing area.

Firecracker



Dishwashing



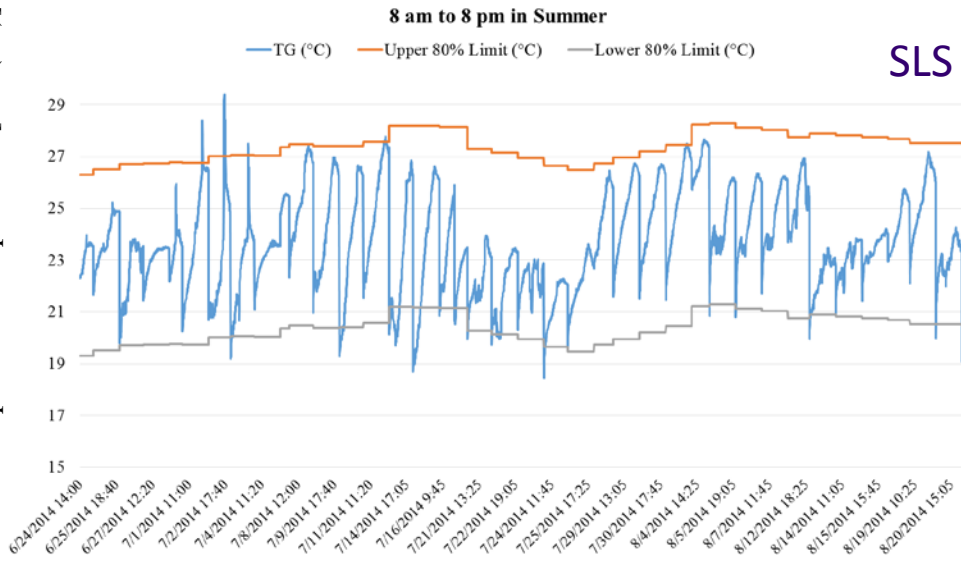
Subjective Measurement: Occupant [Employee] Surveys

- > The survey for office environment was a modified version of Center for the Built Environment of University Berkeley's Occupant Indoor Environmental Quality at <http://www.cbe.berkeley.edu/research/survey.htm>
- > The survey for Husky Den kitchen area was developed based on the research by Stoops et al. supported by ASHRAE for restaurant kitchen environments.

Summer



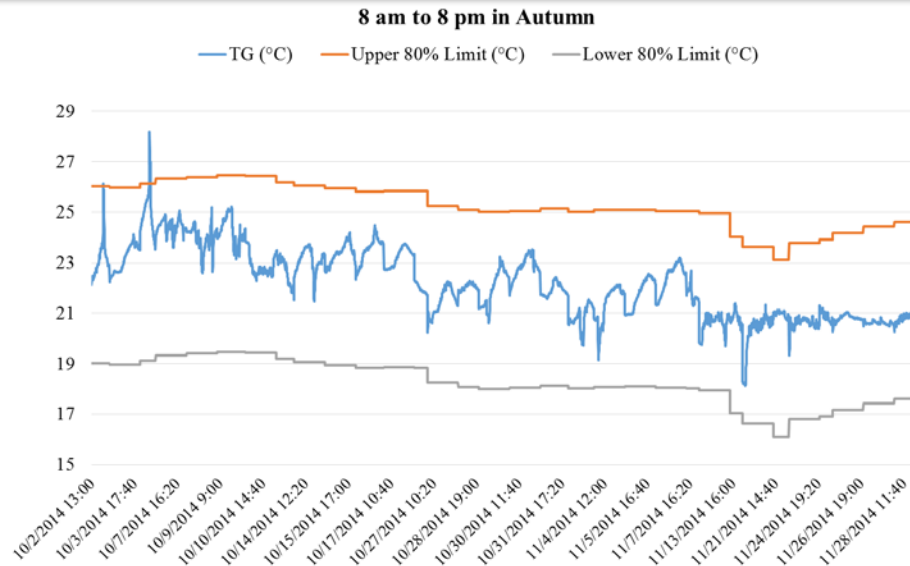
Indoor Operative Temperature [TG (°C)]



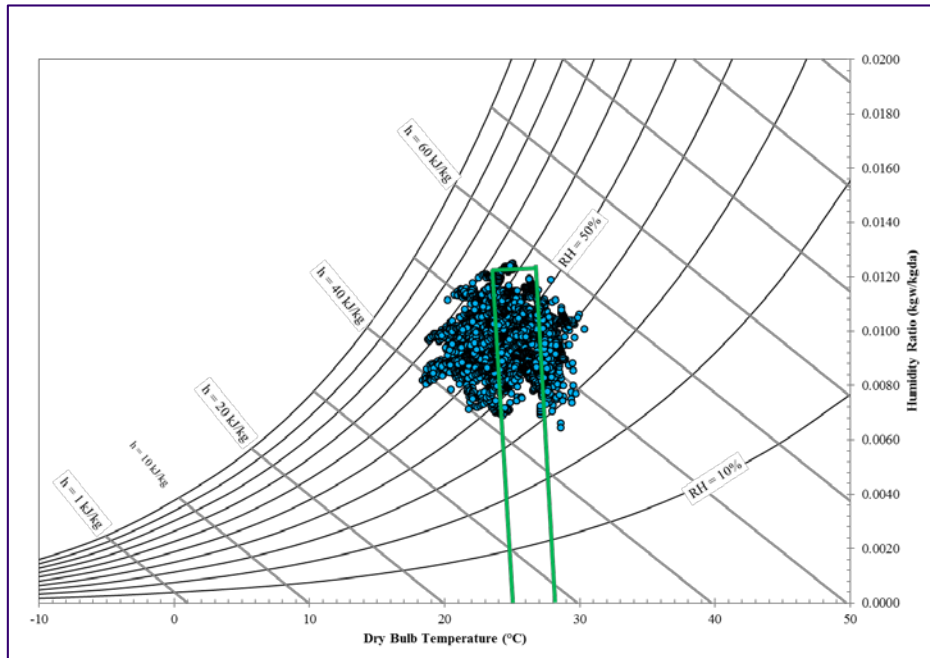
SLS Office

Date

Indoor Operative Temperature [TG (°C)]

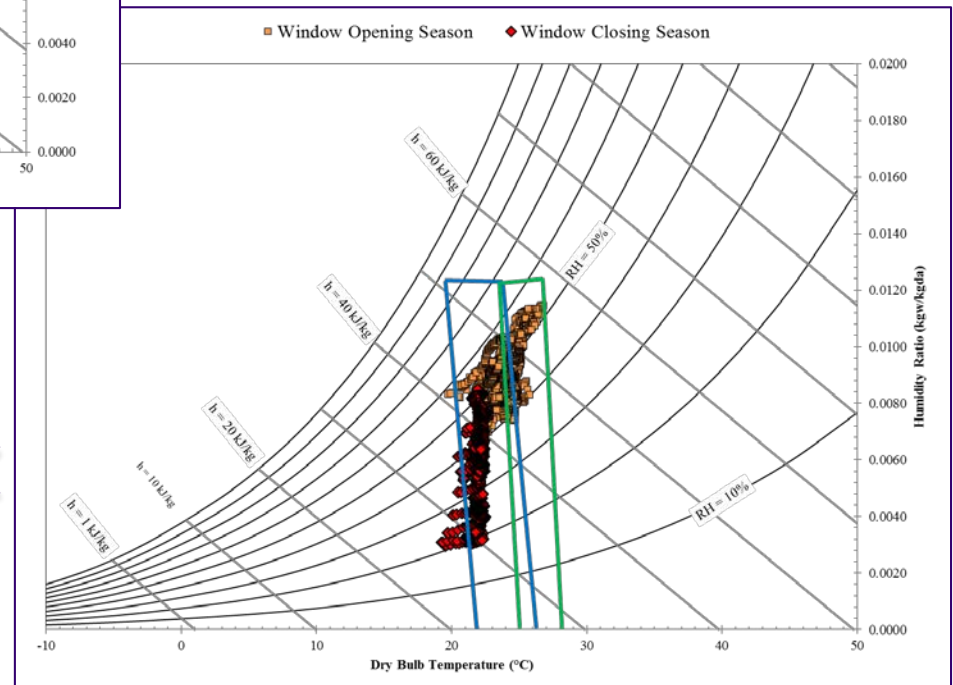


Autumn

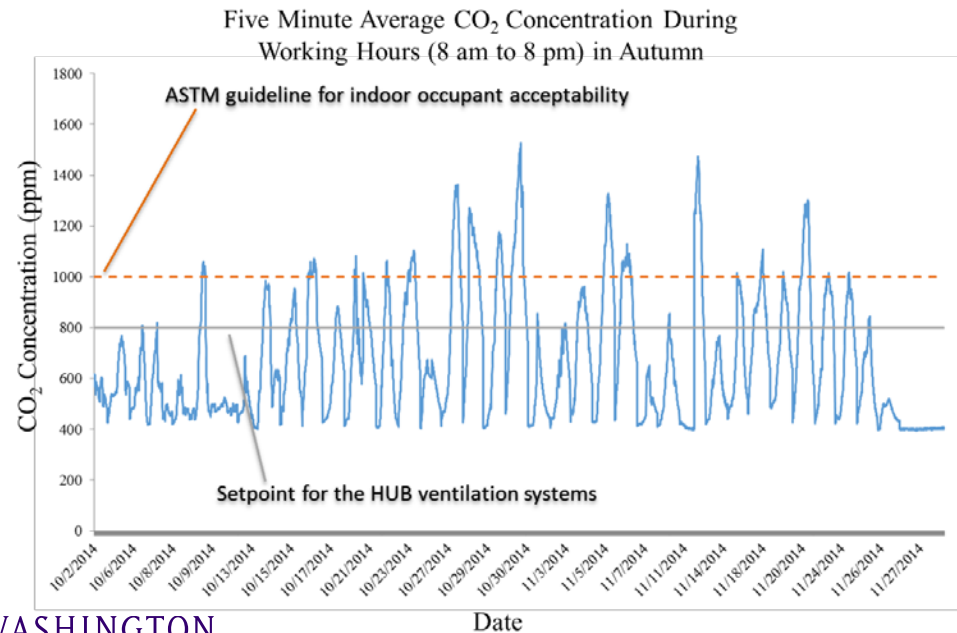
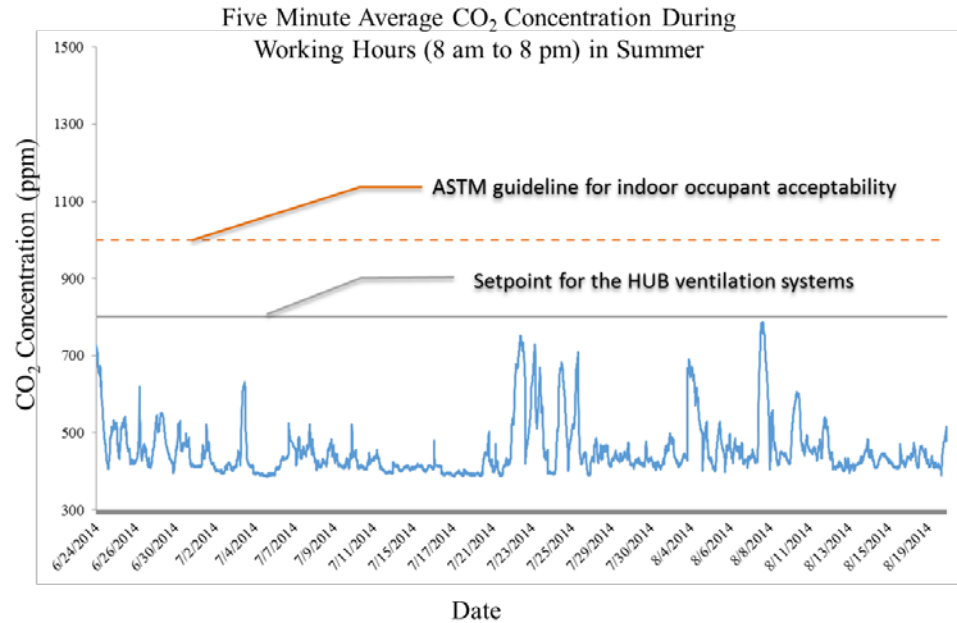


➡ Graphic Comfort Zone for working hours (8 am to 8 pm) in the summer. The solid “boxed” area shows the 0.5 clothing zone.

Graphic Comfort Zone for working hours (8 am to 8 pm) in the autumn in SLS office. The 1.0 (blue solid line) and 0.5 (green solid line) clothing zones are shown.



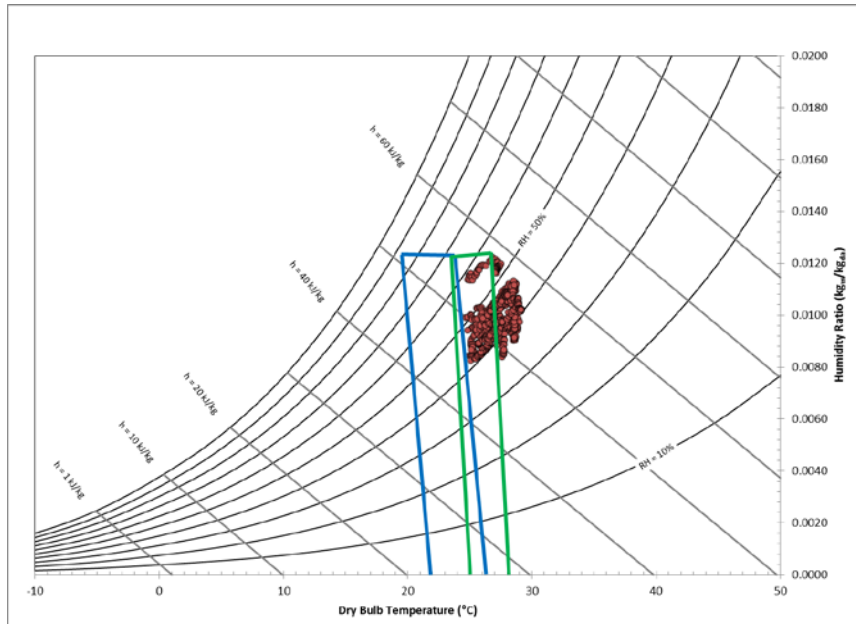
Summer



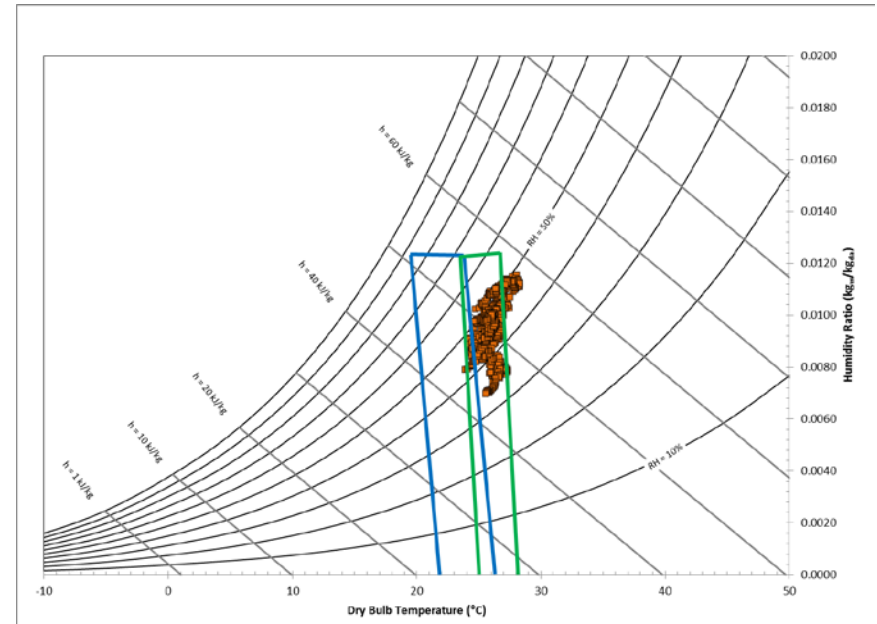
Autumn



Graphic Comfort Zone at Firecracker Station

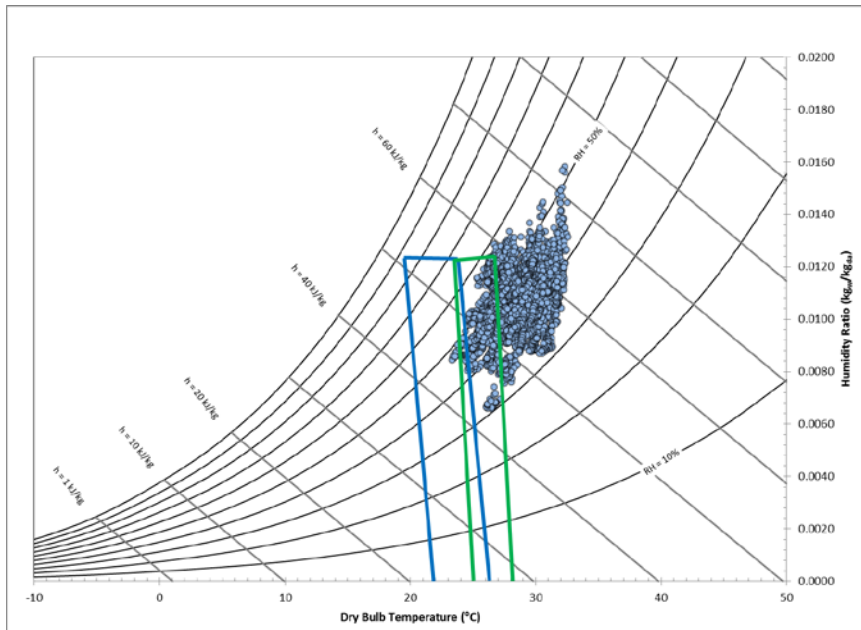


Graphic Comfort Zone for Firecracker (10 am to 4 pm) in the summer. The 1.0(blue solid line) and 0.5 (green solid line) clothing zones are shown.

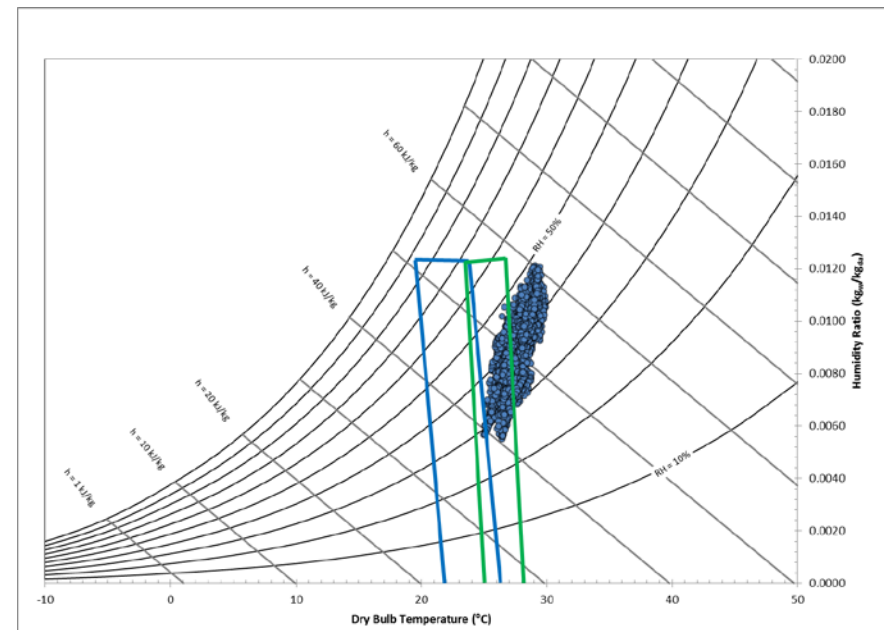


Graphic Comfort Zone for Firecracker (10 am to 4 pm) in the autumn. The 1.0(blue solid line) and 0.5 (green solid line) clothing zones are shown.

Graphic Comfort Zone at Dishwashing Area during Working Hours

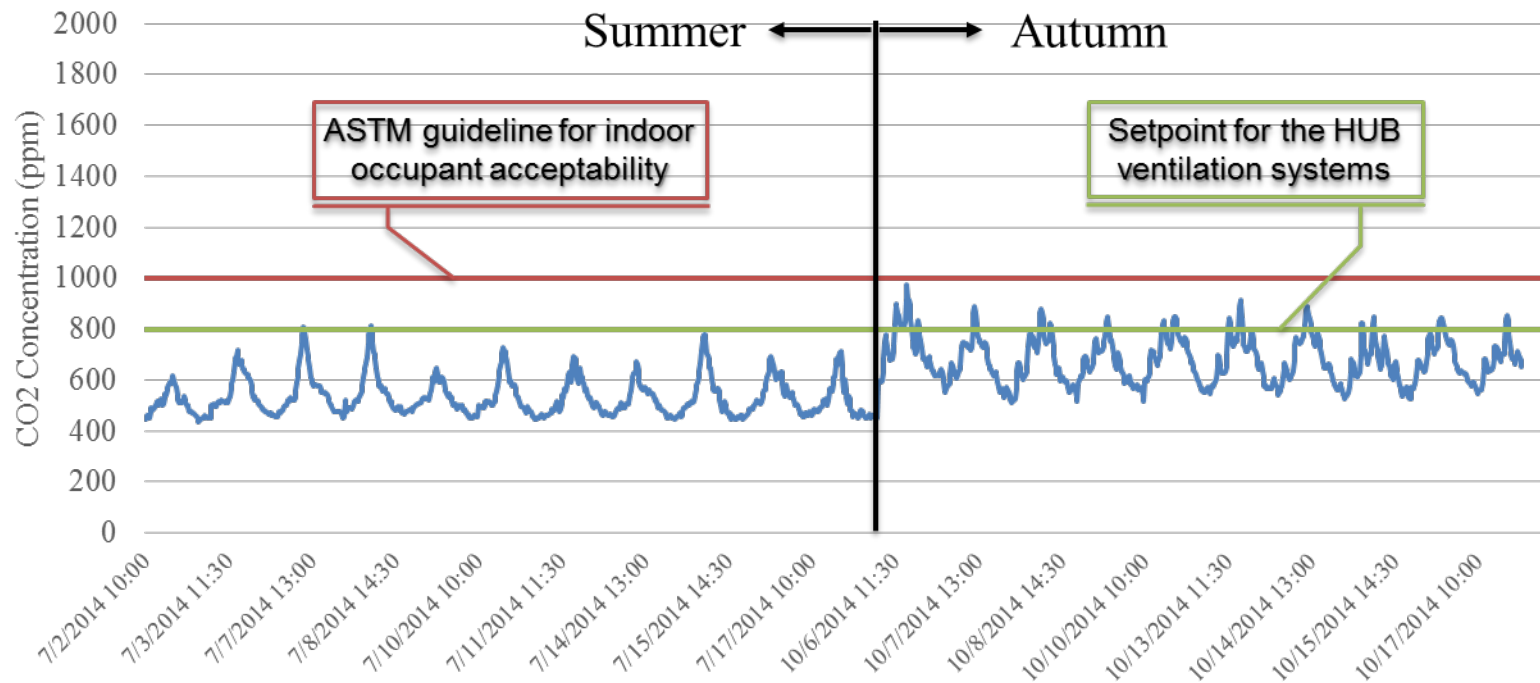


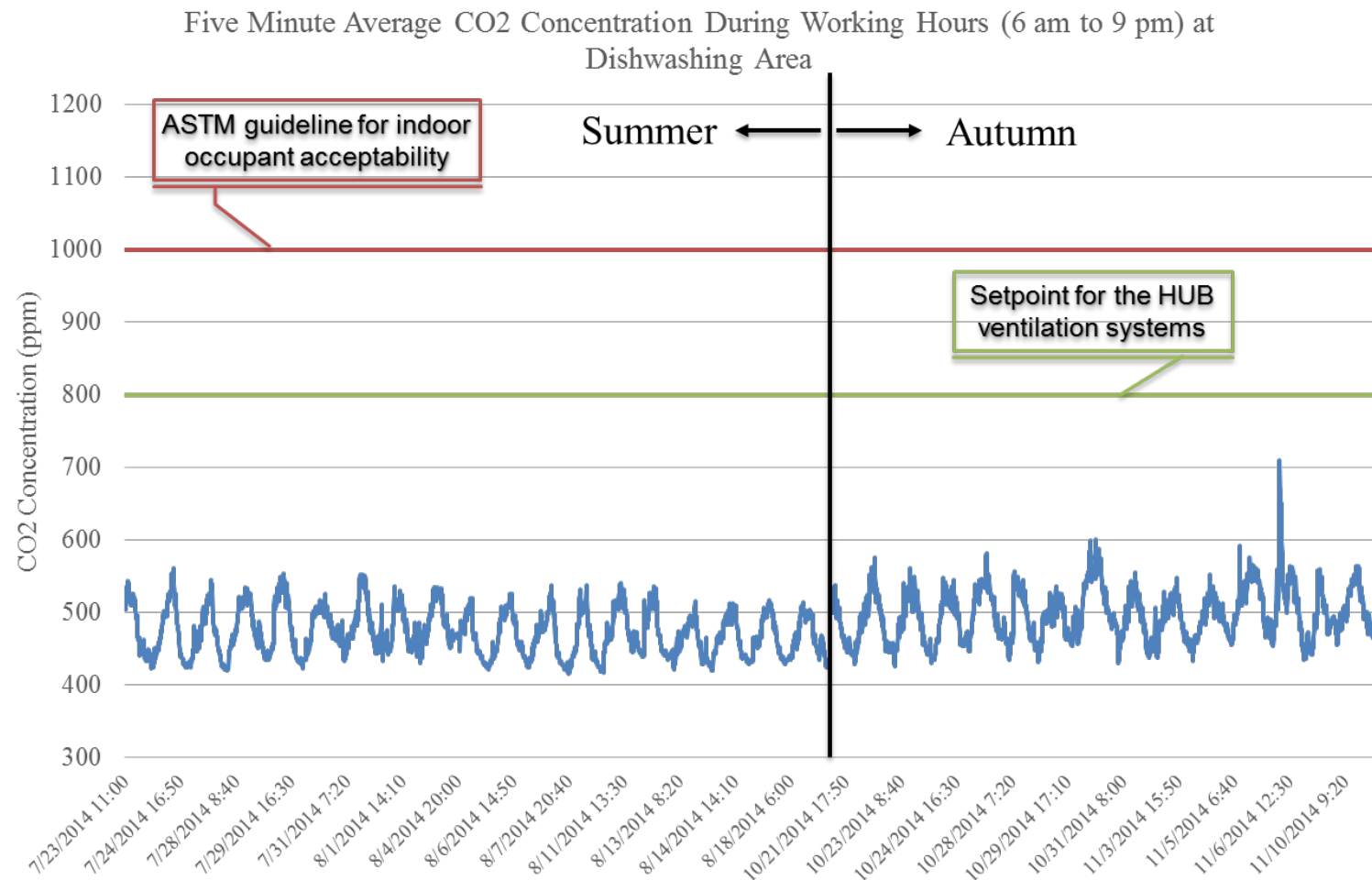
Graphic Comfort Zone for Dishwashing (6 am to 9 pm) in the summer. The 1.0(blue solid line) and 0.5 (green solid line) clothing zones are shown.



Graphic Comfort Zone for Dishwashing (6 am to 9 pm) in the autumn. The 1.0(blue solid line) and 0.5 (green solid line) clothing zones are shown.

Five Minute Average CO₂ Concentration During Working Hours (10 am to 4 pm) at
Firecracker





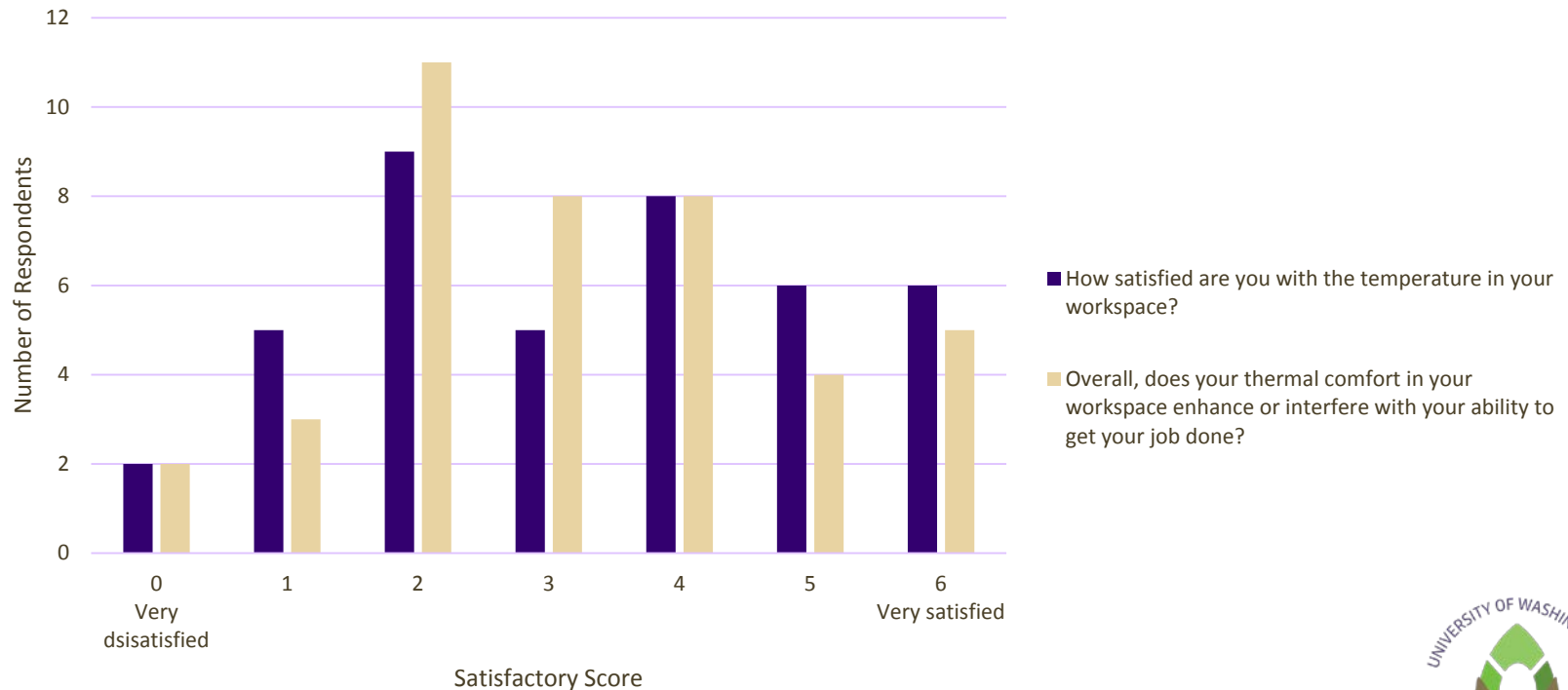
HUB Office Occupant Survey

- > Table below gives the background information of the office survey respondents

| Employees | Number of Respondents | % of | Age (\pm SD) | Height (\pm SD) | Weight (\pm SD) |
|-----------|-----------------------|------|-----------------|--------------------|--------------------|
| | | | Years | m | kg |
| All | 41 | 100% | 31 \pm 13 | 1.71 \pm 0.12 | 75 \pm 23 |
| Male | 14 | 34% | 36 \pm 16 | 1.82 \pm 0.07 | 86 \pm 24 |
| Female | 27 | 66% | 29 \pm 12 | 1.64 \pm 0.09 | 69 \pm 20 |

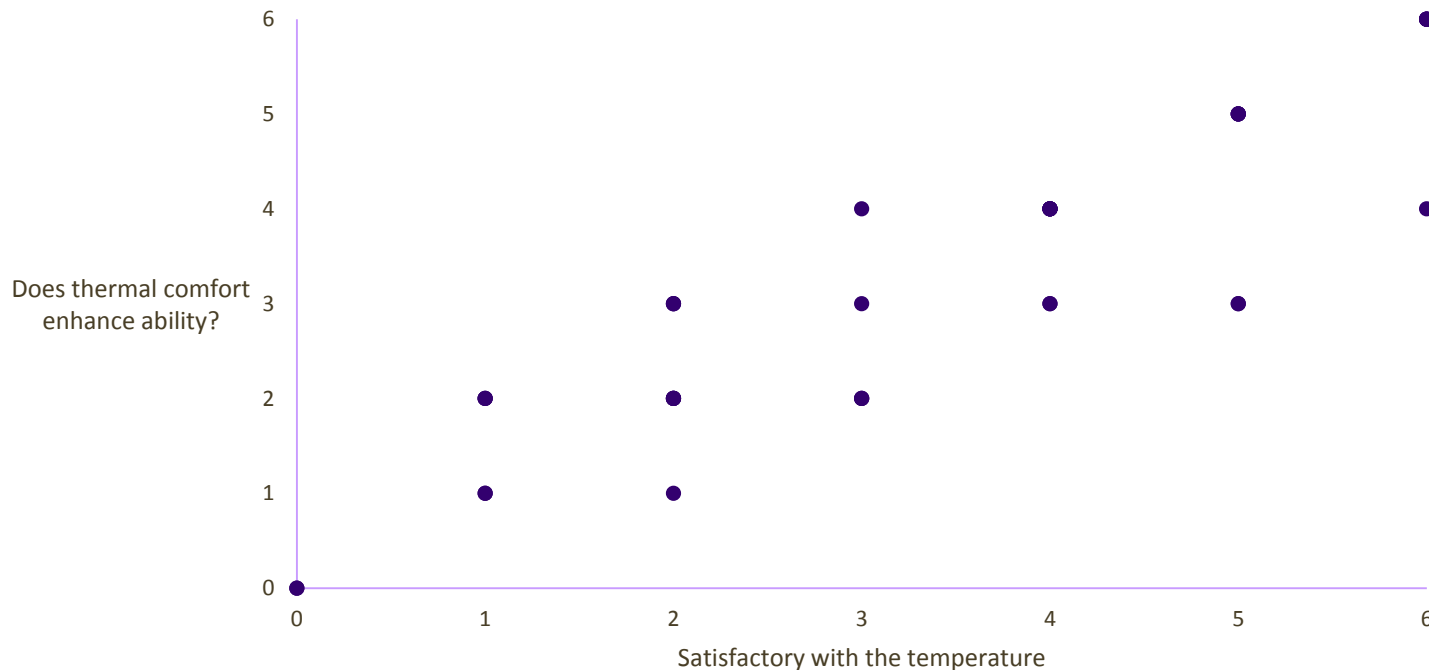
HUB Office Occupant Survey

- > The respondents were evenly spread between satisfied and dissatisfied when asked about the indoor temperature and their thermal comfort.



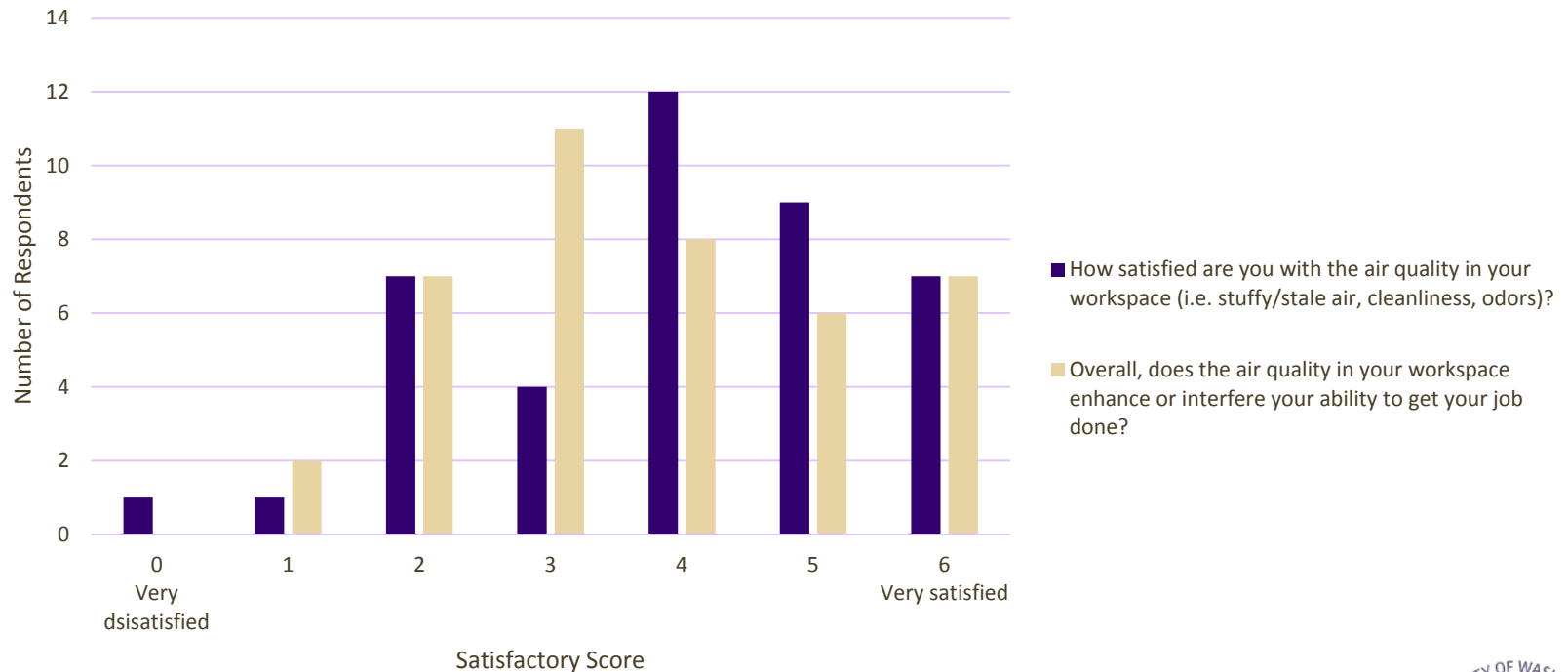
HUB Office Occupant Survey

- > From the survey results, it is clear that respondents connect their thermal comfort directly to indoor temperature. Respondents who were not satisfied with the temperature generally feel the thermal comfort in their workspace interferes their ability to get their job done.



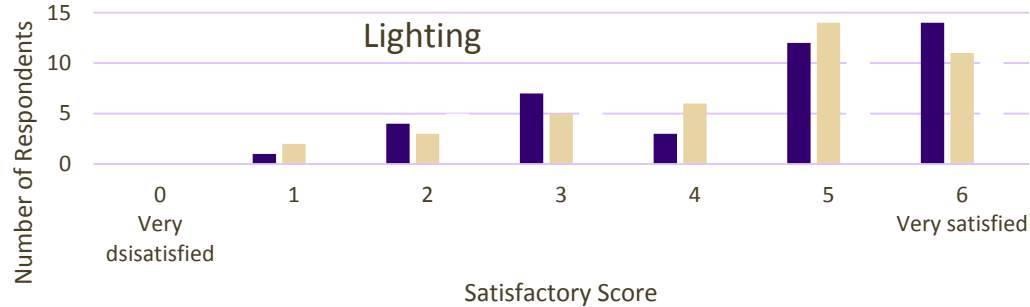
HUB Office Occupant Survey

- > Compared to thermal comfort, respondents were more satisfied with the air quality in their workspace.



HUB Office Occupant Survey

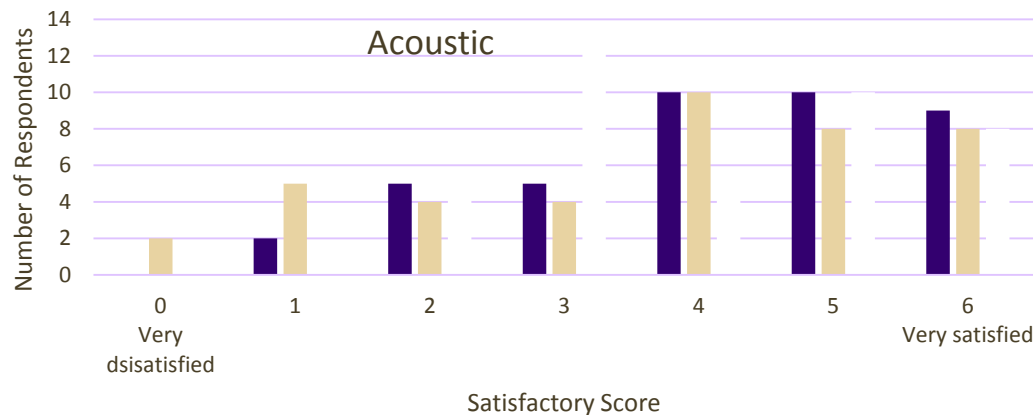
➤ Majority of the respondents were also satisfied with the lighting and acoustic quality of their offices.



■ How satisfied are you with the amount of light in your workspace?

■ How satisfied are you with the visual comfort of the lighting (e.g. glare, reflections, contrast)?

Overall, does the lighting quality enhance or interfere with your ability to get your job done?



■ How satisfied are you with the noise level in your workspace?

■ How satisfied are you with the sound privacy in your workspace (ability to have conversations without your neighbors overhearing and vice versa)?

Overall, does the acoustic quality in your workspace enhance or interfere with your ability to get your job done?

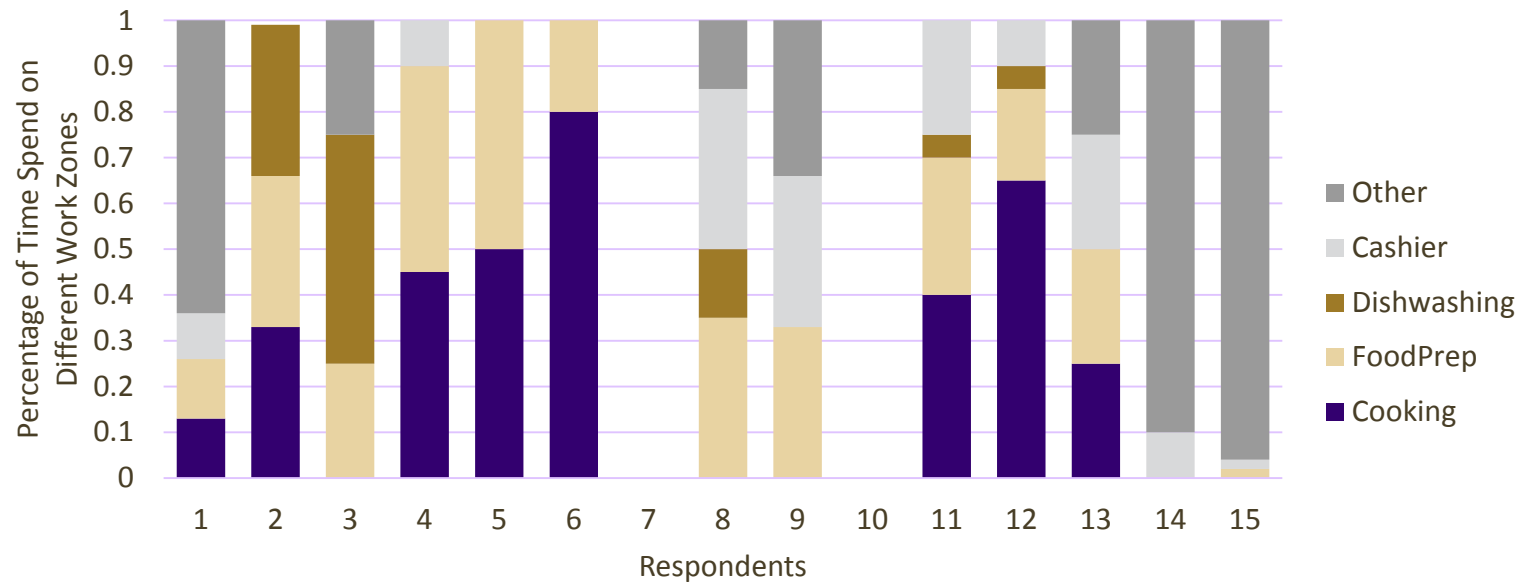
Husky Den Kitchen Survey Results

> Table below contains background information of the survey respondents.

| Respondents | Number of Respondents | % of Respondents | Age (±SD) | Height (±SD) | Weight (±SD) |
|-------------|-----------------------|------------------|-----------|--------------|--------------|
| | | | Years | m | kg |
| All | 15 | 100% | 39±14 | 1.72±0.17 | 82±22 |
| Male | 9 | 60% | 38±15 | 1.79±0.16 | 93±22 |
| Female | 6 | 40% | 40±13 | 1.61±0.13 | 67±11 |

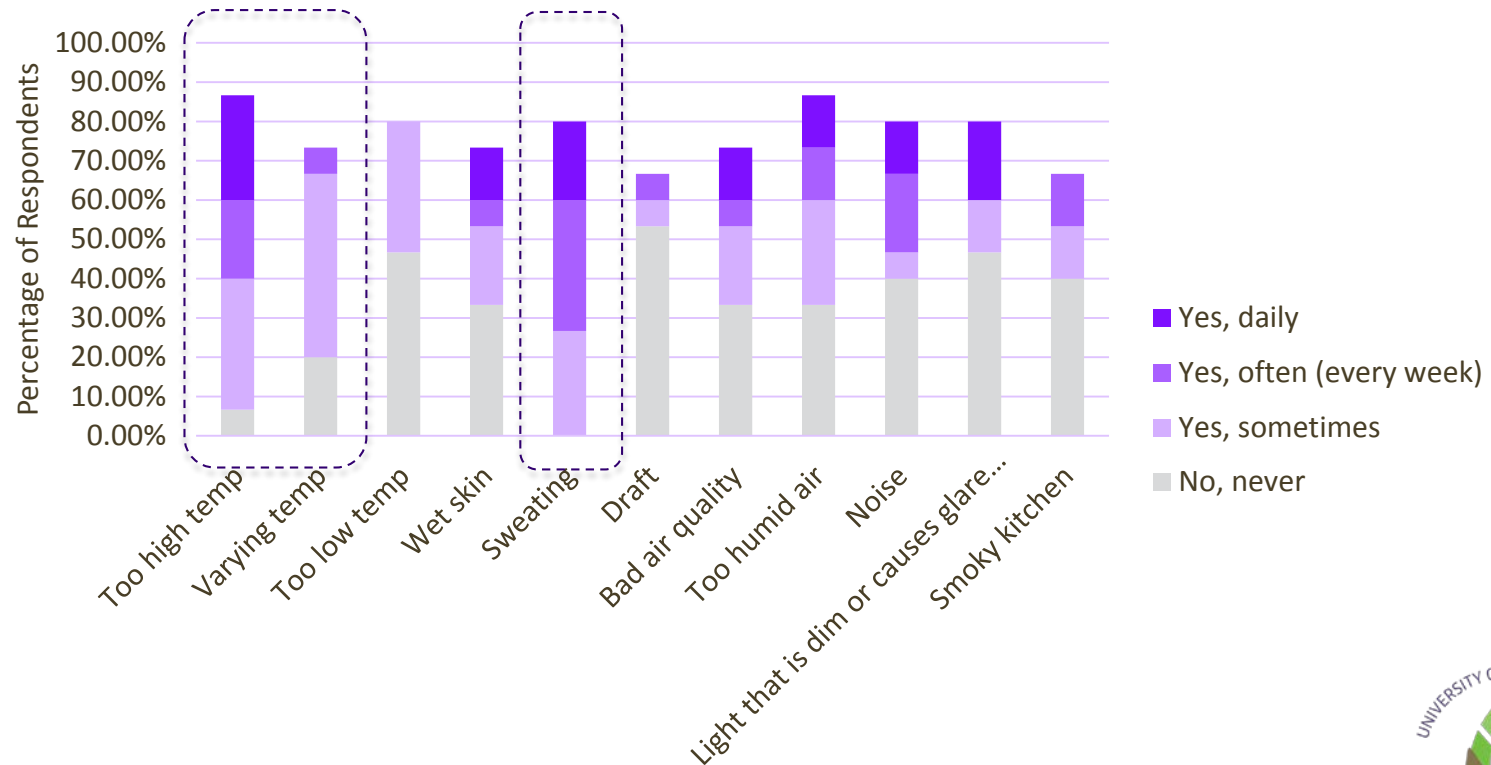
Husky Den Kitchen Survey Results

> The kitchen employees are multi-functional.



Husky Den Kitchen Survey Results

- > Regarding different environmental conditions in the kitchen which could cause discomfort, 'Too High Temperature' and 'Sweating' bothered most of the employees. Complaints of the other conditions were relatively low.



Conclusions

- > Objective and subjective measurements for the offices showed problems of indoor thermal discomfort during the summer and high CO₂ concentrations in the autumn.
- > Objective measurement of the Husky Den kitchen also showed temperature problems which were confirmed by the kitchen surveys.
- > Therefore, LEED Gold status does not automatically ensure thermal comfort for employees, especially in restaurant/ kitchen areas. In-situ calibration is needed to adjust the building ventilation system.

Acknowledgements

- > We would like to thank HUB Associate Director Paul Zuchowski; Carole A. Grayson, JD, Director of Student Legal Services; and Dale T. Askew, General Manager of the Husky Den.
- > We would also like to thank all the employees who filled out surveys.
- > This research was supported by University of Washington's Green Seed Fund.



Thank you!

